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The way to the future has already started: ICAO Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocol evolution update

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Introduction

- Global aviation community is working on standardizing Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocol
- Three mobility solutions under evaluation: Location/Identifier Separation Protocol, Asymmetric Extended Route Optimization and Mobile IPv6 with Extensions
- Communications for aviation dates back to 1920s where AT used colored flags to control takeoffs and landings.
- In 1930s, the Cleveland airport in Ohio was the first to use radio communications for Air Traffic Control (ATC)
- ATC communications technology has experienced many changes since the early days and increased complexity gave rise to new requirements for information exchange
- The modernization and evolution of global aviation requires a transition from analog communications to digital information exchange
- There is an increasing need for critical information exchange over multiple links between air and ground networks

Aviation Operational Networks

The Aircraft Communications Addressing and Reporting System (ACARS)

- Developed by ARINC and in use since late 1970's for transmission of data only (no voice).
- Data link originally provisioned for services between the aircraft and Airline Operations Centers Systems, later expanded to support Air Navigation Service Providers and the aircraft.
- Airborne system consists of a Control Unit (CU) and a Management.
- Ground subnetwork is made-up of Remote Ground Radio Stations that are connected to a Datalink Service Processor
- Character-oriented
  - Send 7-bit characters
  - Maximum message of 220 characters
- Modulation on VHF band:
  - 2400 bps (bits-per-second) over AM (amplitude modulation) using MSK (Minimum Shift Keying) in the 25kHz channels.
- Aircraft Messages generated automatically based on discrete events e.g. brake release, Out of gate, Off the ground, On the ground, Into gate = OOOI

Aviation Operational Networks

Aeronautical Telecommunications Network (ATN)/ Open Systems Interconnection (OSI)

- Based on the OSI reference model
- OSI model divides the communications functions into seven layers.
- ATN design to integrate data communications networks and services.
  - Consists of application entities and communication services that enable ground, air-to-ground, and avionics data subnetworks to interoperate
  - standardizes common interfaces, services, and protocols.
- ATN specified to provide data communications for Air Traffic Services Communication, Aeronautical Operational Control, Aeronautical Administrative Communication and Aeronautical Passenger Communication

Standardization

- 2010 - First publication of ICAO Manual on the Aeronautical Telecommunication Network using Internet Protocol Suite Standards and Protocol - Document 9896
  - Defined data communications protocols and services to be used for implementing ATN using the IPS
  - Provided technical specifications that addressed security, network and transport protocols, described applications
  - Based on IPv6 protocol
- 2015 Document 9896 R2 revised to include VoIP
- Document 9896 undergoing third revision to include mobility, multilink operations, DNS, naming and addressing.
- 2016 - EUROCAE WG-108 and RTCA SC-223 are collaborating in developing
  - Minimum Aviation System Performance Standards
  - IPS Technology Profile - used to provide useful guidance to the technology designers
  - Development use mature and proven IETF RCF standards to addresses both airborne and ground segments

Proposed Mobility Solutions - LISP

Locator/Identifier Separation Protocol

- Developed by CISCO Corporation – RFC 6830
  - Splits address into Endpoint Identifier (EID) and Routing Locator (RLOC)
    - RLOC – Interdomain routing
    - EID – Intradomain routing
  - Overlay Architecture, requires LISP capable routers, uses packet encapsulation, UDP
  - Decouples data (EID, RLOC space) and control plane (Mapping System similar to DNS)
  - Incremental Implementation
- LISP based mobility solutions can be derived as follows:
  - Aircraft based LISP Mobility
  - Ground based LISP Mobility
- Attributes
  - Optimized mobility – No anchor points, minimal/scoped state
  - Streamlined load balancing and path preference model
  - Guaranteed Packet delivery – Lossless mobility and convergence
  - Simplicity of Aircraft functionality (minimal to no additions)
  - Global Scale through Modular Design
  - Interoperability for Incremental/regional adoption
  - Normalized behavior for unicast and multicast with seamless mobility

Proposed Mobility Solutions - AERO

Asymmetric Extended Route Optimization

- Based on IETF standards and Internet-Drafts
  - Neighbor Discovery, BGP, Standard Encapsulation techniques
  - Overlay architecture (UDP)
- AERO Components - Clients, Proxys, Servers and Relays
  - AERO **Clients** are Aircraft that connect to data link subnetworks via aviation data links (also ATC/AOC/etc.)
  - AERO **Proxys** connect data link subnetworks to the ATN/IPS Internetwork, placed at boundaries
  - AERO **Servers** - BGP routing overlay over the Internetwork, tracks AERO Clients.
  - AERO **Relays** – COTS BGP Router
- Internetwork is a link that connects all AERO neighbors??
- Scalable by adding server/relay systems.
- AERO supports:
  - IPv6 Neighbor Discovery (ND) protocol
  - dynamic link selection
  - mobility management
  - Multilink
  - quality of service (QoS) signaling
  - route optimization

Proposed Mobility Solutions - MIPv6 with Extensions

Proxy Mobile Internet Protocol v. 6

- ICAO Document 9896, Version 2 defines the data communications protocols and services to be used for implementing the ICAO ATN/IPS.
- The Mobile IPv6 uses Generic Registry-Registrar Protocol Requirements, RFC 3375 and employs optional extensions.
- ICAO Document 9896 does not support multilink operations
- The fundamental approach to Mobile IP is packet forwarding
- Mobile Node (MN) has a permanent home address (HoA) and a dynamic CoA that changes as the mobile node changes its point of attachment.
- A Correspondent Node (CN), which can be any peer node an aircraft communicates with, sends packets to the home agent (HA) of the mobile node.
- Aircraft reaches the Home Agent (HA) through normal IP routing.
- Upon receipt of a packet from the CN (e.g. AT Control), the HA forwards these packets to the MN at its current CoA.
- The HA tunnels the original packet in another packet with its own source address and a destination address of the current CoA
- Mobile IPv6 with Multiple CoA: Extensions to bind more than one CoA to a HoA
- Mobile IPv6 with Flow Bindings: is used to identify a particular flow which is bound to one or more CoAs

Emerging Operational Concepts

- Voice Air-Ground Communications, the DOC 9896 provides the VoIP requirements only on the ground part of the existing VHF A/G communication infrastructure
- Unmanned aircraft fast evolution increasing demand for RPAS to operate in non-segregated airspace and at aerodromes.
- Small Unmanned Aircraft Systems (sUAS) vehicles are proliferating and regulation has been develop to enable safe operations.
- Unmanned Traffic Management (UTM) concepts to enable safe, efficient and organized use of airspace for altitudes between 0 and 400 feet
- Urban Air Mobility (UAM) is a NASA project that will investigate and develop technologies for airspace and vertiport management with the intent to enable urban missions by small electrified vehicles

Conclusions

- Need to enable seamless dissemination of information over diverse sub-networks
- ATN/IPS will enable mobility, multi-link, multi-homing, multi-service, end-to-end interconnectivity and support the integration of new vehicle types navigating existing and emerging airspace configurations
- Global aviation will eventually transition to a native IPS system.
- ATN/IPS will meet the challenging needs of different airspace users, vehicle types and enable continued aviation advances well into the future